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(21) International Application Number: PCT/SE93/00069 (22) International Filing Date: 29 January 1993 (29.01.93) (30) Priority data: 9200289-8 31 January 1992 (31.01.92) SE (71) Applicant (for all designated States except US): SVEDALA-ARBRA AB [SE/SE]; S-233 00 Svedala (SE). (72) Inventors; and (75) Inventors/Applicants (for US only) : MALONE, William [GB/GB]; 3 Centenary Quadrant, Holytown, Motherwell ML1 4ZZ (GB). SVENSSON, Arvid, Lennart [SE/SE]; Hakvingegatan 4, S-230 44 Bunkflostrand (SE). SCOTT, Alexander, James [GB/GB]; 10 Palmer Crescent, Strathaven, Lanarks ML10 6ER (GB).		(74) Agent: AWAPATENT AB; Box 5117, S-200 71 Malmö (SE). (81) Designated States: AT, AU, BB, BG, BR, CA, CH, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, LK, LU, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, SN, TD, TG). Published <i>With international search report.</i> <i>In English translation (filed in Swedish).</i>
(54) Title: METHOD FOR CONTROLLING A GYRATORY CRUSHER		
<div data-bbox="191 1134 730 1564"> (57) Abstract A gyratory crusher has two crushing shells (4, 5) defining between them a crushing gap (6). In operation, the crushing gap is adjusted as a function of the determined crushing-shell wear calculated on the basis of reference data on the established rate of wear of the crushing shells (4, 5) in previous crushing operations involving the same or a similar raw material. To adjust the particle size distribution of the crushed goods and obtain the desired particle size distribution curve, the crusher is operated with brief periods of alternatingly different settings of the width of the crushing gap (6) and/or with alternating crushing power or crushing force. </div> <div data-bbox="747 1113 1412 1995"> </div>		

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METHOD FOR CONTROLLING A GYRATORY CRUSHER

The present invention relates to a method for controlling a gyratory crusher so as to maintain a substantially constant crushing gap or to adjust the particle size distribution of the crushed goods, or both to maintain a substantially constant crushing gap and to adjust the particle distribution of the crushed goods.

The invention relates to a gyratory crusher having a crushing head with a first crushing shell, and a second crushing shell defining, together with the first crushing shell, a crushing gap whose width is adjustable by changing the relative position of the first and the second crushing shell in the axial direction by means of a hydraulic adjusting device, the material to be crushed being introduced into the crushing gap and a driving device causing the crushing head to execute a gyratory pendulum movement.

In the operation of such gyratory crushers, the crushing head is so adjusted that a certain predetermined width of the gap between the first, inner crushing shell and the second, outer crushing shell is obtained. The adjustment operation is performed manually and in such a manner that there is a certain safety margin up to maximum permissible crusher load. Since the load on the crusher will vary during the crushing operation, too narrow a gap would involve the risk of overload on the crusher with ensuing damage. As crushing proceeds, the shell surfaces are worn, which increases the gap width, thereby reducing productivity. To counteract this development, the axial position of the crushing head is adjusted gradually, either manually or automatically, to obtain the gap width as originally set.

Swedish Patent Specification 8601504-7 (SE-B-456,798) teaches a method for controlling such a gyratory crusher in order to avoid damage caused by caking in the crushing

chamber between the outer and the inner crushing shell. Caking may arise if the material is supplied incorrectly or if the composition of the material supplied is not right (e.g. if the material contains too much moisture or too many pieces of stone which are harder than the remaining material). Thus, caking may cause high, but brief load peaks resulting in brief pressure increases, so-called pressure surges. Prior-art crushers are therefore equipped with a load-relieving system dealing with such temporary load peaks. In the above Swedish patent, such a system for dealing with temporary load peaks is combined with adjustment based on a determined value of the number of pressure surges in the hydraulic fluid of the adjusting device that exceed a predetermined pressure level in a given period of time, the relative position of the crushing shells being changed depending on this value to increase the width of the crushing gap if the calculated number of pressure surges exceeds a predetermined sum.

PCT Publication W087/01305 discloses a readjustment of the width of the crushing gap by now and then bringing the crushing shells together to obtain a reference value for the subsequent adjustment of the crushing gap during the next operational period. Thus, this publication merely describes conventional calibration of a cone crusher during a crushing operation.

EP-A-0 429 237 discloses a safety device for preventing overload of the cone crusher with ensuing damage. In this device, the upper part of the chamber housing of the crusher is pressed downwards towards the main frame of the crusher. If there is an overload, the downwardly-directed force is relieved by temporarily raising the upper part of the chamber housing of the crusher. The use of this safety device does not involve any controlled variation of the crushing force.

Swedish Published Application 8601353-9 (SE-B-456,138) and the corresponding US Patent US-A-4,856,716 disclose a method for operating a cone crusher, in which

the power consumption, the pressure load on the crushing head and the width of the crushing gap are continuously measured. The measured values are then used for maintaining the width of the crushing gap on a level above a
5 determined minimum value by correlating the power consumption and the pressure load in accordance with a set formula.

The present invention represents an improvement of the invention described in the above Swedish Patent Specification 8601504-7 (SE-B-456,798) and has, as one
10 object, to provide safer and more effective control of the operation of the crusher as well as an enhanced adjustability in respect of the particle size distribution of the crushed goods.

15 This and other objects of the invention are achieved if the crusher is operated in accordance with the method defined in the appended claims.

In the inventive operation of a gyratory crusher having two crushing shells defining between them a crushing gap, the width of the gap is adjusted depending on
20 the determined wear of the crushing shells. The wear is calculated on the basis of reference data on the established rate of wear of the crushing shells in previous crushing operations involving the same or a similar raw
25 material. To adjust the particle size distribution of the crushed goods and obtain the desired particle size distribution curve, the crusher may, in the method according to the invention, be operated with brief periods of alternately different settings of the width of the
30 crushing gap and/or with alternating crushing power or crushing force.

According to one aspect, the invention thus provides a method for controlling a gyratory crusher of the type mentioned by way of introduction. This aspect of the
35 invention is distinguished by performing the adjustment of the crushing gap depending on an estimated wear of the

crushing shells calculated on the basis of reference data on the established rate of wear of the crushing shells in previous crushing operations involving the same or a similar raw material. According to this aspect of the invention, the gyratory crusher is first calibrated, either by bringing the two shells of the crusher into engagement with each other or by inserting a piece of lead or some other spacing element between the shells. After a certain period of crushing, another calibration is performed in the same way to determine the axial displacement of the crushing head in relation to the frame of the crusher required to regain the desired width of the gap, thereby to enable determination of the rate of wear under given crushing conditions. In the continued crushing operation, the calculated rate of wear is then used as input data for the control device of the crusher for automatically displacing the crushing head in relation to the outer crushing shell to compensate for the estimated wear. However, since the wear is not always the same per unit of time, the adjustment should, by way of precaution, be performed at a value slightly below the estimated value.

According to another aspect of the invention, the gyratory crusher is controlled in such a manner that the particle size distribution of the crushed goods is adjusted to the desired particle size distribution curve. According to this aspect, the crusher is operated with alternating brief periods of different settings of the width of the crushing gap. For example, the crusher may be operated, during one operational period, with a set maximum crushing power or crushing force and, during another operational period, with a set constant width of the crushing gap.

During the operational period with the set maximum crushing power or crushing force, the axial position of the crushing head in relation to the frame of the crusher

should be monitored to avoid any direct contact between the two crushing shells.

In an especially preferred embodiment of the invention, the relative position of the crushing shells can be readjusted, during the operational period with a set crushing power or crushing force and/or the operational period with a set gap width, by simultaneous monitoring of the axial position of the crushing head in relation to the frame of the crusher and monitoring of the set maximum crushing power or crushing force, and readjustment of the axial position of the crushing head in relation to the frame of the crusher on the basis of reference data from previous crushing operations involving the same or a similar raw material.

The invention will be described in more detail below with reference to the accompanying drawings, in which Fig. 1 schematically illustrates a gyratory crusher with associated driving, adjusting and control devices; Fig. 2 contains a series of particle size distribution curves obtained for different settings of the crushing gap at an approximately constant gap width during the entire crushing operation; and Fig. 3 is a diagram showing a desired as well as an attained particle size distribution curve achievable by adjusting the crushing gap in accordance with the invention.

In the embodiment illustrated, it is assumed that the position of the crushing head (i.e. the position of the first crushing shell) is changed when the relative position of the crushing shells is altered, and that the width of the crushing gap is reduced when the crushing head is lifted in the axial direction.

The gyratory crusher shown in Fig. 1 comprises a shaft 1 which is eccentrically mounted at the lower end 2. At the upper end, the shaft carries a crushing head 3. A first, inner crushing shell 4 is mounted on the outside

of the crushing head. In the machine frame 16, a second, outer and annular crushing shell is mounted so as to surround the inner crushing shell 4 with which it defines a crushing chamber. This chamber is in the form of a gap 6 which in axial section, as shown in Fig. 1, has a width that decreases downwards. The shaft 1 is vertically adjustable by means of a hydraulic adjusting device 15. The crusher also comprises a motor 10 which, in operation, causes the shaft 1 and the crushing head 3 to execute a gyratory pendulum movement, i.e. a movement during which the two crushing shells 4, 5 approach one another along a rotating generatrix and move away from one another along a diametrically opposed generatrix.

In operation, the crusher is controlled by a control device 11 which, at an input 12', receives input signals from a transducer 12 arranged at the motor and measuring the load on the motor. At an input 13', the control device 11 receives signals from a pressure transducer 13 sensing the pressure of the hydraulic fluid in the adjusting device 15. At an input 14', the control device 11 in addition receives signals from a level transducer 14 sensing the vertical position of the shaft 1 in relation to the machine frame.

When the crusher is to be put in operation, a calibration is first performed. Thus, the pump 18 pumps hydraulic fluid into the tank 7 until the shaft 1 has reached its vertically lowermost position. In this position, the distance between the crushing head 1 and a fixed point in the machine frame is measured. The measured value is then supplied to the control unit as representing the distance corresponding to the signal from the level transducer 14. Subsequently, hydraulic fluid is pumped into the system from the tank 7 until the inner shell 4 is applied against the outer shell 5. When the inner shell thus comes into contact with the outer shell, there is a pressure surge in the hydraulic fluid

which is recorded by the pressure transducer 13. In this position, the above distance is measured and supplied to the control unit as representing the signal from the level transducer 14 for this position. Knowing the gap
5 angle between the inner shell 4 and the outer shell 5, one may then determine, with the aid of the two calibration values measured, the gap width for any position of the shaft 1.

In this method, calibration is based on a position
10 in which the inner and the outer shell touch each other. However, it is possible to base calibration on a position in which the crushing shells do not touch but in which a set gap width has been established by measuring with the aid of a piece of lead or some other spacing element
15 introduced into the gap. Otherwise, calibration is performed in a similar manner.

When the method according to the invention is utilised to achieve automatic calibration and to maintain the crushing gap substantially constant during the crush-
20 ing operation, the wear of the crushing shells is calculated. This is done by determining the distance of displacement from the first manual calibration to the next manual calibration (compared with the same reference gap) and taking into consideration the time the crusher has
25 operated under load (i.e. not idling). Then, the displacement measured is divided by the operating time, giving a measurement of the rate of displacement or wear, e.g. in millimetres per hour.

With the knowledge of how much the shaft 1 has to be
30 displaced per unit of time owing to wear, the control unit 11 is, in continued operation, caused to automatically compensate for the wear at regular intervals, e.g. once per hour. For safety reasons, wear compensation should not be carried out to the full, since the wear of
35 the crushing shells may vary with time. This is so because the abrading properties of the crushed material

are not constant, the size distribution of the supplied material varies or the load of the crusher is not constant. Several factors may concur.

After the first occasion of calculation mentioned
5 above, the circuits of the control unit are connected for automatic calibration. The control unit adjusts the axial position of the crushing head depending on the rate of displacement or wear measured. As a matter of precaution, compensation may be carried out by a factor of e.g. 0.3
10 or 0.5 of the estimated wear.

After a certain period of operation, another manual calibration is performed to obtain a second occasion of calculation. The control unit may be programmed not to make any new calculation prognoses until there has been a
15 displacement of e.g. 10 mm from the preceding prognosis. If this manual calibration shows that the rate of wear is lower than expected, the safety margins can be reduced so that compensation for the estimated wear can be increased in subsequent operation. If, on the other hand, the wear,
20 and consequently the rate of displacement, varies considerably with time (e.g. if different types of goods or goods having highly varying properties are being crushed), the safety factor may perhaps never be raised above e.g. 0.3. It may even be necessary to interrupt automatic
25 calibration.

Naturally, manual calibrations can be performed whenever desired, but calculations and subsequent check-ups should always be carried out after a predetermined minimum distance of displacement (10 mm in the above example) if
30 measuring errors are not to have an adverse effect on the result.

The automatic calibration described above is advantageous in that it eliminates a common inconvenience, namely that the actual gap increases as the shells are
35 worn, despite the fact that the gap set by the control device remains the same. In prior-art techniques, the set gap is only correct for a brief period after calibration.

If automatic calibration is performed in accordance with the invention, the control device 11 will gradually lift the main shaft 1 and reduce the gap 6, such that the desired, set gap is maintained for a much longer period of time. Thus, the actual gap will not increase as rapidly as before, and much fewer manual calibrations of the gyratory crusher are thus required when using the invention.

When using the invention, the control device 11 may also control the crushing operation by maintaining a specific, selected crushing power or crushing force. If, in this type of operation, use is made of the above automatic compensation for wear, more time may elapse between successive manual calibrations of the gap.

The control technique may be utilised if one wishes to obtain an essentially constant size of the product as well as automatic compensation for wear. If so, the crushing procedure begins with manual adjustment of the gap until the desired product has been obtained. Then, power and force are read, and the resulting values are then inputted as maximum permissible power and force. The control device 11 will then operate at the set power and force and automatic wear compensation meaning that the control device 11 adjusts the main shaft 1 upwards to compensate for the wear and to maintain the load.

When the invention is used for affecting the particle size distribution of the crushed goods, the crusher should be operated during brief periods of alternately different settings of the width of the crushing gap 6. This aspect of the invention will be described in more detail below.

If a gyratory crusher is operated with an essentially constant crushing gap during the crushing operation, particle size distribution curves of the type shown in Fig. 2 are obtained. If, for instance, the gap is 24 mm, the particle size distribution curve farthest to the right can be obtained during an operational period. Likewise, the other curves can be obtained with gap widths of, respectively,

21 mm, 18 mm, 15 mm and 12 mm. When the gap width is altered, the general shape of the curves is thus basically maintained, but there is an anticlockwise angular rotation when the crushing gap is reduced. However, one often
5 desires to obtain particle size distribution curves of completely different shapes and types, which may depend on the purpose of the crushed product. The invention provides the possibility of affecting the particle size distribution of the crushed product by periodic alterations of the
10 operational conditions.

Fig. 3 shows a desired particle size distribution curve for a product, indicated by a full line. Such a curve cannot be obtained by crushing with a constant gap in accordance with Fig. 2. However, the idea is to combine
15 two or more product yields into a new desired product yield. In the method according to the invention, this can be achieved by causing the control device to periodically change the gap width between two set positions. These positions can be obtained by switching between two different types of operational periods, namely a first operational period in which the automatic setting system
20 strives to maintain constant a specific set high crushing power for a high degree of crushing of the material through a comparatively narrow crushing gap, and a second operational period in which the automatic setting system
25 strives to maintain constant a specific comparatively broad set gap for a lower degree of crushing of the material. The control device 11 can be programmed so as to provide switching between these two operational positions
30 at desired points of time. For instance, the highest possible power and force can be allowed during one period to give maximum crushing. The yield obtained during this period may then contain enough fine material, while there is a lack of coarse material. More coarse material can be
35 produced by running the second operational period with a larger gap than in the preceding period. If the crusher is allowed to work for e.g. 60 s with the narrow gap and 45 s

with the broader gap, this results in two different product yields which are physically separated immediately after the crusher. After the customary few intermediate storages and reloadings, the two yields are, however, 5 mixed into a single product having the desired distribution of fine and coarse material. The durations of the different operational periods should be chosen while taking into consideration the handling of the crushed goods after crushing, as well as the agitation and mixing 10 achieved during handling. Durations of 30-120 s may be suitable, depending on the aimed-at particle size distribution curve.

According to this aspect of the invention, the crusher can thus be operated with a set high crushing 15 power or crushing force during the one operational period and operated with a set crushing gap width during the other operational period. Alternatively, the crusher may, during the one operational period, be operated with a set narrow crushing gap and, during another operational 20 period, be operated with a broad crushing gap. In both instances, the crusher can be operated while monitoring the axial position of the crushing head in relation to the frame of the crusher in order to avoid any direct contact between the two crushing shells. A third possibility is to 25 operate the crusher during different periods of alternating high and low crushing power or crushing force.

In the above examples, use is made of two different sets of operation parameters in the modification of the particle size distribution of the crushed goods. If desired, 30 use may, of course, be made of three or more different sets of operation parameters to obtain additional advantages.

Preferably, the crusher is however preset, during the operational period with set maximum crushing power or 35 crushing force, at a specific chosen gap width. The relative position of the crushing shells is then readjusted by simultaneous monitoring of the axial position of the

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crushing head in relation to the frame of the crusher and monitoring of the set maximum crushing power or crushing force, as well as by readjustment of the axial position of the crushing head in relation to the frame of the crusher .

5 on the basis of reference data from previous crushing operations involving the same or a similar raw material. #

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CLAIMS

1. A method for controlling a gyratory crusher having a crushing head (3) with a first crushing shell (4), and a second crushing shell (5) defining, together with the first crushing shell (4), a crushing gap (6) whose width is adjustable by changing the relative position of the first and the second crushing shell (4, 5) in the axial direction by means of a hydraulic adjusting device (15), the material to be crushed being introduced into the crushing gap (6), and a driving device (10) causing the crushing head (3) to execute a gyratory pendulum movement, c h a r a c t e r i s e d by adjusting the particle size distribution of the crushed goods to the desired particle size distribution curve by operating the crusher with brief periods of alternately different settings of the width of the crushing gap (6).

2. A method as set forth in claim 1, c h a r a c - t e r i s e d by operating the crusher during one operational period with a set crushing power or crushing force by adjustment of the width of the crushing gap (6), and operating the crusher during another operational period with a predetermined set width of the crushing gap (6).

3. A method as set forth in claim 1 or 2, c h a r - a c t e r i s e d by monitoring, during operation of the crusher, the axial position of the crushing head (3) in relation to the frame (16) of the crusher to avoid any direct contact between the two crushing shells (4, 5).

4. A method as set forth in claim 1 or 3, c h a r - a c t e r i s e d by operating the crusher with brief periods of alternately different settings of the crushing power or crushing force by variation of the width of the crushing gap.

5. A method as set forth in claim 2 and claim 3 or 4, c h a r a c t e r i s e d by readjusting, during the operational period with set crushing power or crushing force

and/or the operational period with set width of the gap (6), the relative position of the crushing shells (4, 5) by simultaneous monitoring of the axial position of the crushing head (3) in relation to the frame of the crusher and monitoring of the set maximum crushing power or crushing force, and readjustment of the axial position of the crushing head in relation to the frame of the crusher on the basis of reference data from previous crushing operations involving the same or a similar raw material.

6. A method as set forth in claim 2 and claim 3 or 4, characterised by so controlling the crusher, during operational periods with a broad crushing gap (6), either set at a predetermined value or maintained at such a setting that it gives the desired set crushing motor power or crushing force, that the relative position of the crushing shells (4, 5) is readjusted by simultaneous monitoring of the axial position of the crushing head (3) in relation to the frame of the crusher and monitoring of the set limit for the crushing motor power or crushing force, such controlling of the crusher being performed by readjustment of the axial position of the crushing head in relation to the frame of the crusher to compensate for wear calculated on the basis of reference data on the established rate of wear in previous crushing operations involving the same or a similar raw material.

7. A method for controlling a gyratory crusher having a crushing head (3) with a first crushing shell (4), and a second crushing shell (5) defining, together with the first crushing shell (4), a crushing gap (6) whose width is adjustable by changing the relative position of the first and the second crushing shell (4, 5) in the axial direction by means of a hydraulic adjusting device (15), the material to be crushed being introduced into the crushing gap (6) and a driving device (10) causing the crushing head (3) to execute a gyratory pendulum movement, the crushing operation being controlled to maintain a predetermined set crushing gap or to proceed with a crushing

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gap width varying with time and resulting in the desired set crushing motor power or crushing force, c h a r a c -
t e r i s e d by adjusting the crushing gap depending on
an estimated crushing-shell wear calculated on the basis
5 of reference data on the established rate of wear of the
crushing shells (4, 5) in previous crushing operations,
involving the same or a similar raw material.

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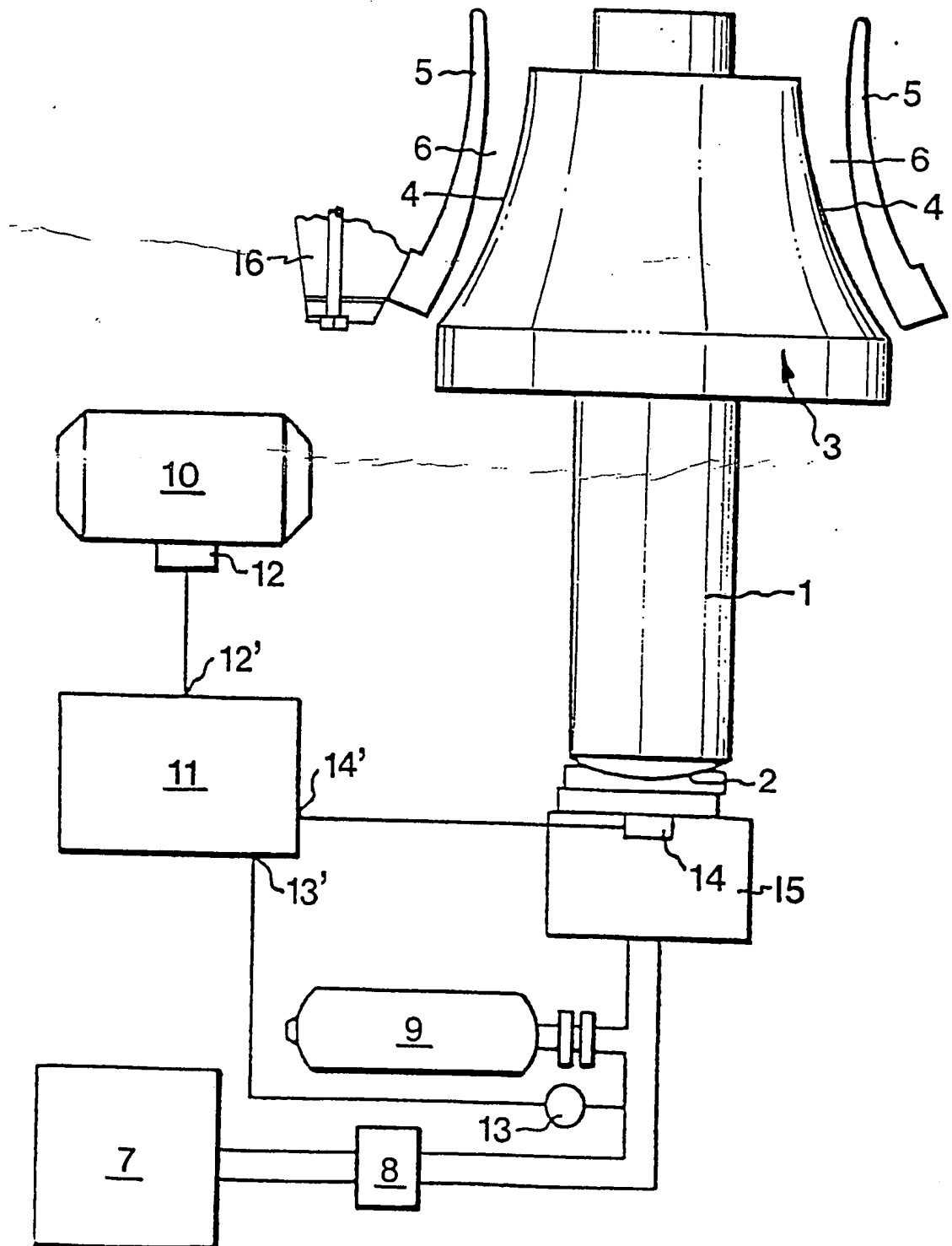
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FIG.1



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FIG.2

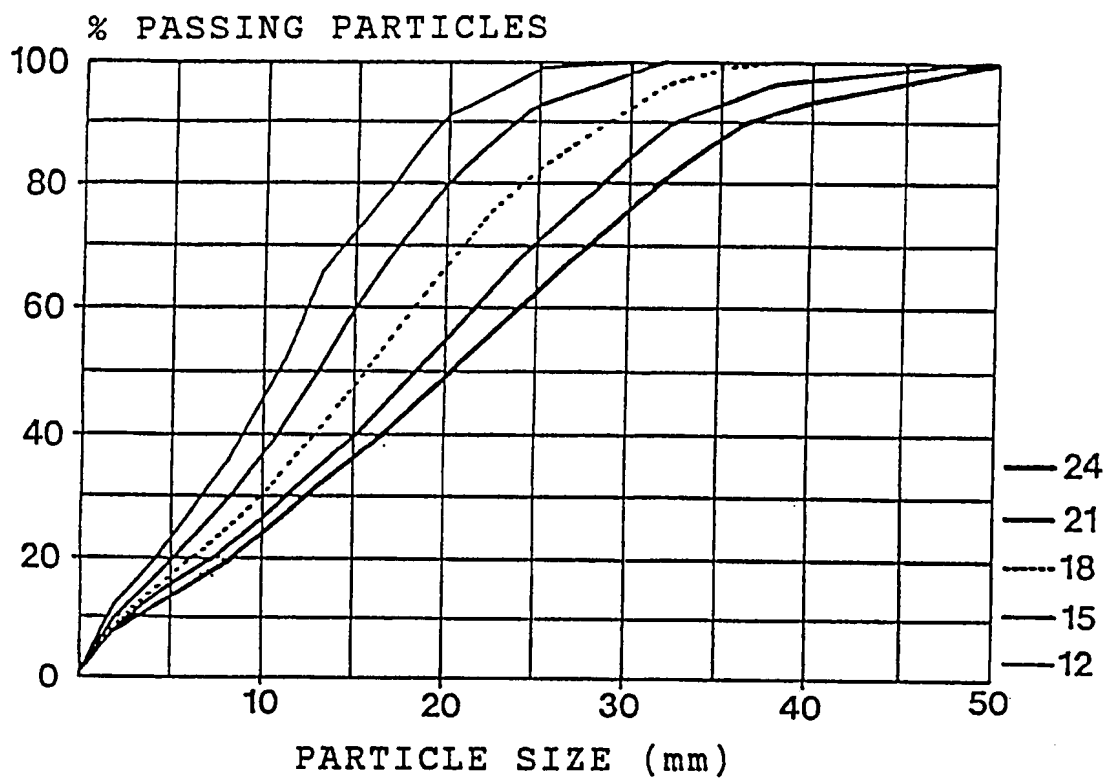
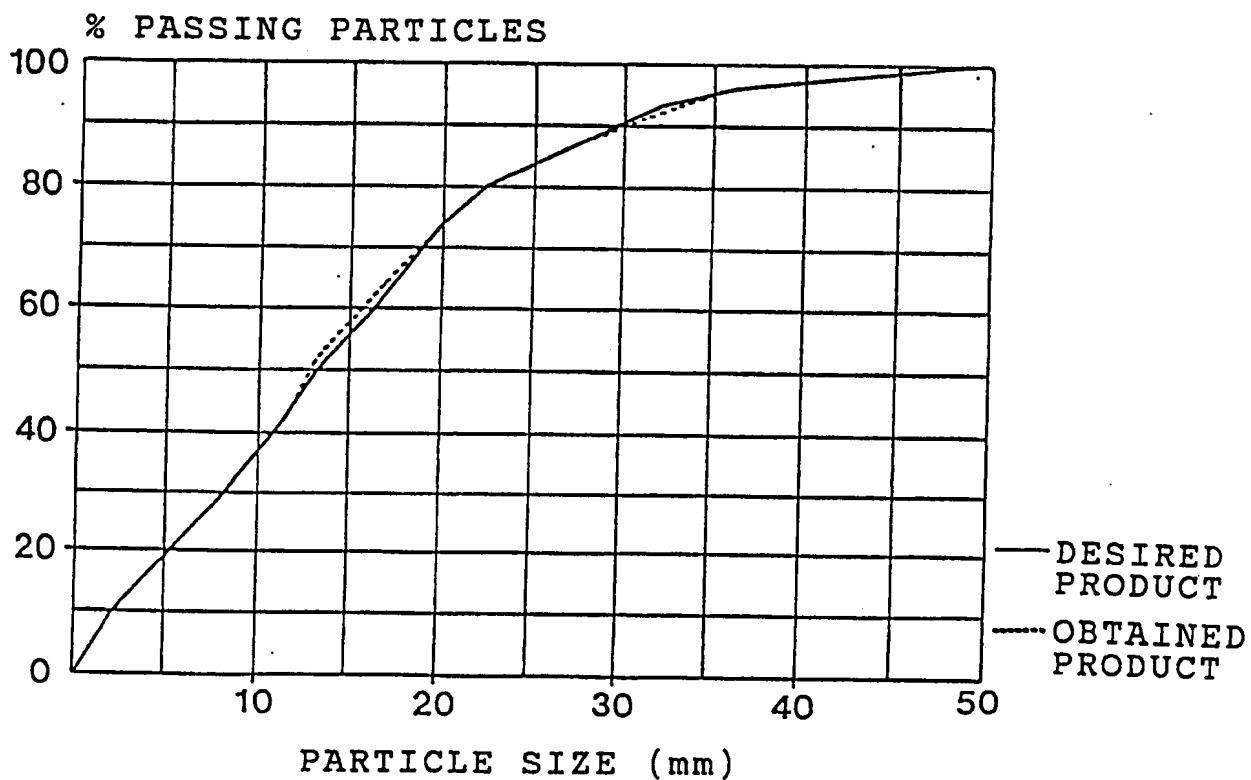


FIG.3



A. CLASSIFICATION OF SUBJECT MATTER

IPC5: B02C 2/00, B02C 25/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: B02C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	SE, B, 456798 (SVEDALA-ARBRA AB), 7 November 1988 (07.11.88), page 3, line 9 - line 33, the figure	4-7
A	--	1-3
Y	EP, A2, 0429237 (NORDBERG INC.), 29 May 1991 (29.05.91), column 4, line 31 - line 32, figure 1, claim 1	4
A	--	1-3,5-7

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 93/00069

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO, A1, 8701305 (FRIED. KRUPP GESELLSCHAFT MIT BESCHRÄNKTER HAFTUNG ET AL), 12 March 1987 (12.03.87), abstract, the figure	5-7
A	---	1-4
A	SE, B, 456138 (BOLIDEN AB), 12 Sept 1988 (12.09.88), page 5, line 14 - line 29, figure 2, claim 1 -----	1-7

INTERNATIONAL SEARCH REPORT
Information on patent family members

31/03/93

International application No.

PCT/SE 93/00069

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